Appendix C

Session 1:
History of Wind Power

1.0 Introduction: History of Wind Power in Hawaii

1.1.1 Session 1 Presenter:

Warren Bollmeier, PICHTR

Presentation charts follow

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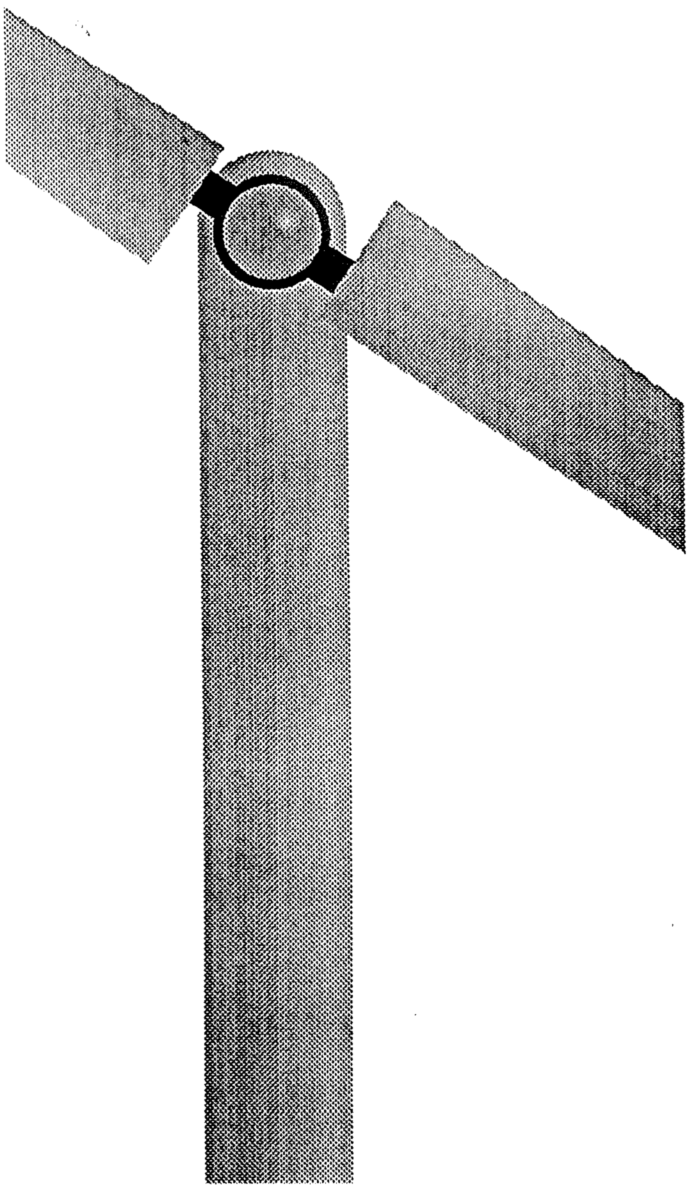

Introduction

1. Early Uses of Windpower in Hawaii
2. Renaissance of Windpower
3. Commercial Activities
4. Future for Windpower in Hawaii
5. Workshop Objectives and Agenda

Renaissance of Windpower

1. State of Hawaii leadership
2. Government Support:
   - Research Development & Demonstration (RD&D)
   - market conditioning

Renaissance of Windpower

3. Utility Leadership: HECO:

- MOD-OA and MOD-5B programs
- MECO: Windane Wind Turbine and the DBEDT/Zond Wind-Diesel Hybrid Project
- HELCO: integration of windpower -- relatively high penetration
- HEI: formation of Hawaii Electric Renewable Systems

Renaissance of Windpower

4. University involvement:

- resource assessment: Meteorology Department and the Hawaii Natural Energy Institute (HNEI)
- RD&D: Wind Energy Battery Storage Test Facility at Kahua Ranch (HNEI)
- public awareness: windpower workshops and hosted Windpower '88

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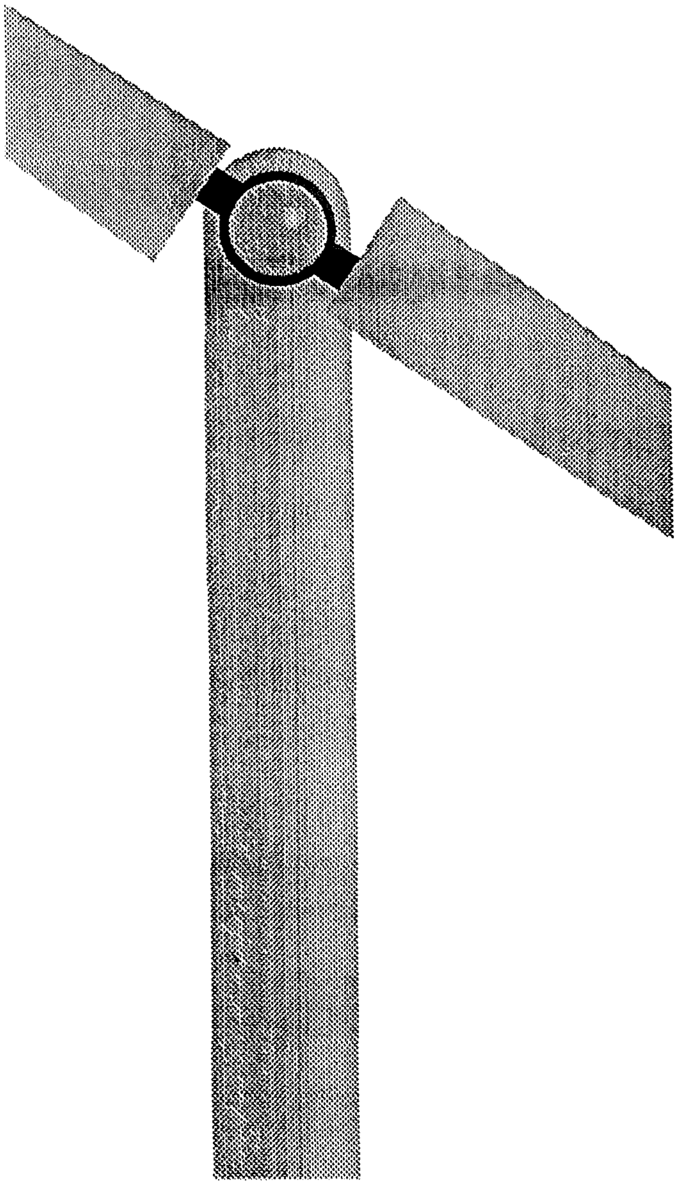

Renaissance of Windpower

5. Industry planning:

- encouraged by the Federal and State tax incentives
- drawing from the Federal wind program RD&D activities
- utilizing resource assessment activities in Hawaii
- investigation of windfarm sites

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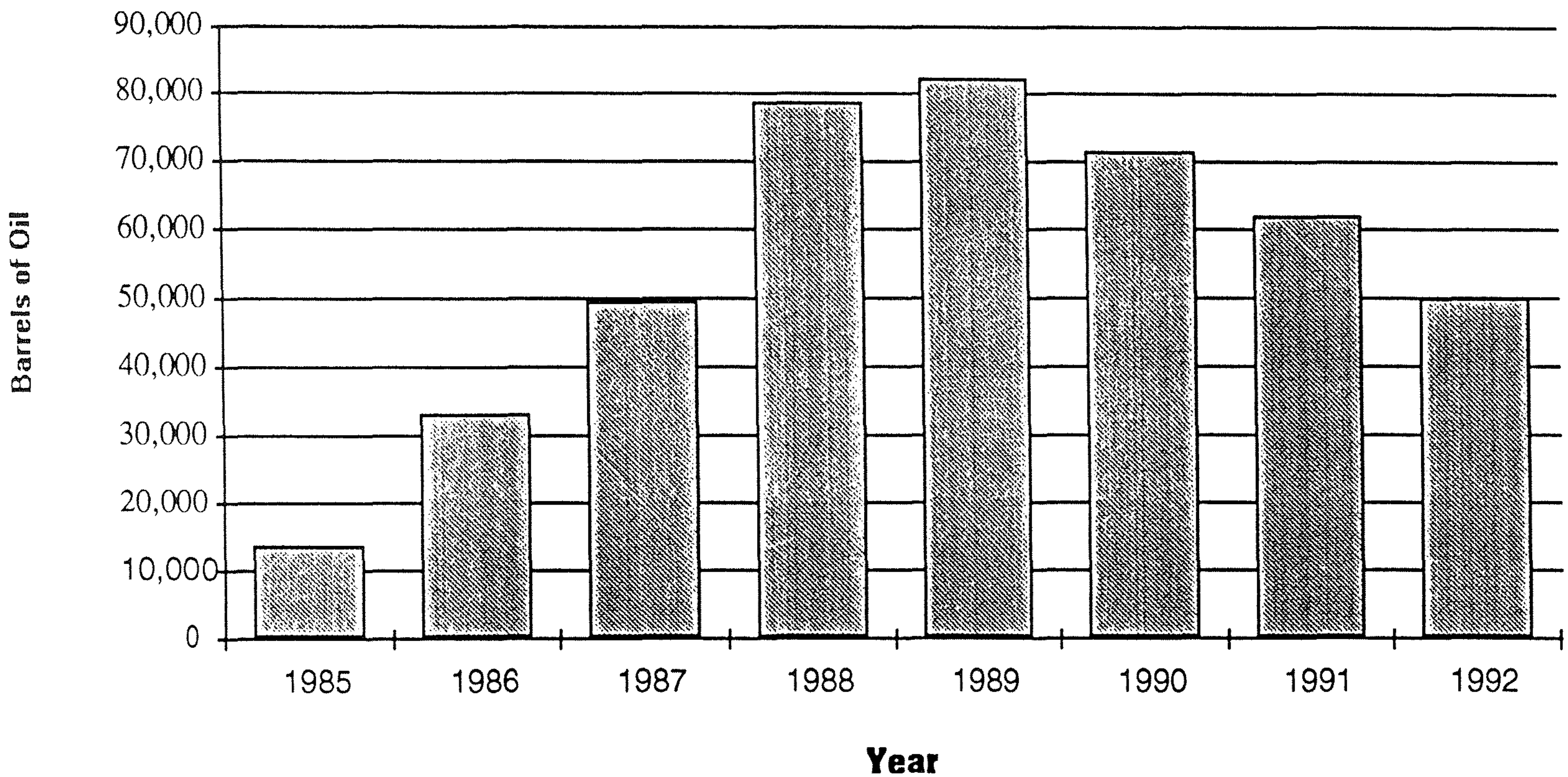
Commercial Windfarms

Project	Kahua Ranch	Lalamilo Wells	Makani Moa'e	Makani Ho'olapa	Kamaoa
Owner	Kahua Ranch Limited	Lalamilo Ventures	Makani Uwila Power Co.	Makani Uwila Power Co. Partners	Kamaoa
Location	Kahua Ranch	Puako, Hawaii	Kahuku, Oahu	Kahuku Point	South Point
Terrain	Mountain pass	Basically flat	Complex	Complex	Mod. Complex
Wind	9.0 m/s (20 mph)	7.6 m/s (17 mph)	8.1 m/s (18 mph)	8.1 m/s (18 mph)	7.7 m/s (17 mph)
Capacity	3.4 MW	2.3 MW	9 MW	3.2 MW	9.25 MW
Cost	N/A	N/A	$25M	$15M	$11.7M
O.D.	1983 to Present	1985 to Present	1985 to Present	1987 to Present	1988 to Present
Turbines	Jacobs (198)	Jacobs (120)	Westinghouse	MOD-5B	Mitsubishi
	1-17.5 kW (18) 2-17.5 kW (180)	20 kW (81) 17.5 kW (39)	600 kW (15)	3.2 MW (1)	250 kW (37)
Rotor	8.0 m (26')	8.0 m (26') 8.6 m (29')	43.3 m (142')	97.6 m (320')	21.9 m (72')
Status	300 kW (18))	1.7 MW (90)	7.8 MW (13)	3.2 MW (1)	9.25 MW (37)

Barrels of Oil Saved by Hawaii's Windfarms

All barrel values consider the particular utility's yearly heat rates and average BTU contents per barrel.



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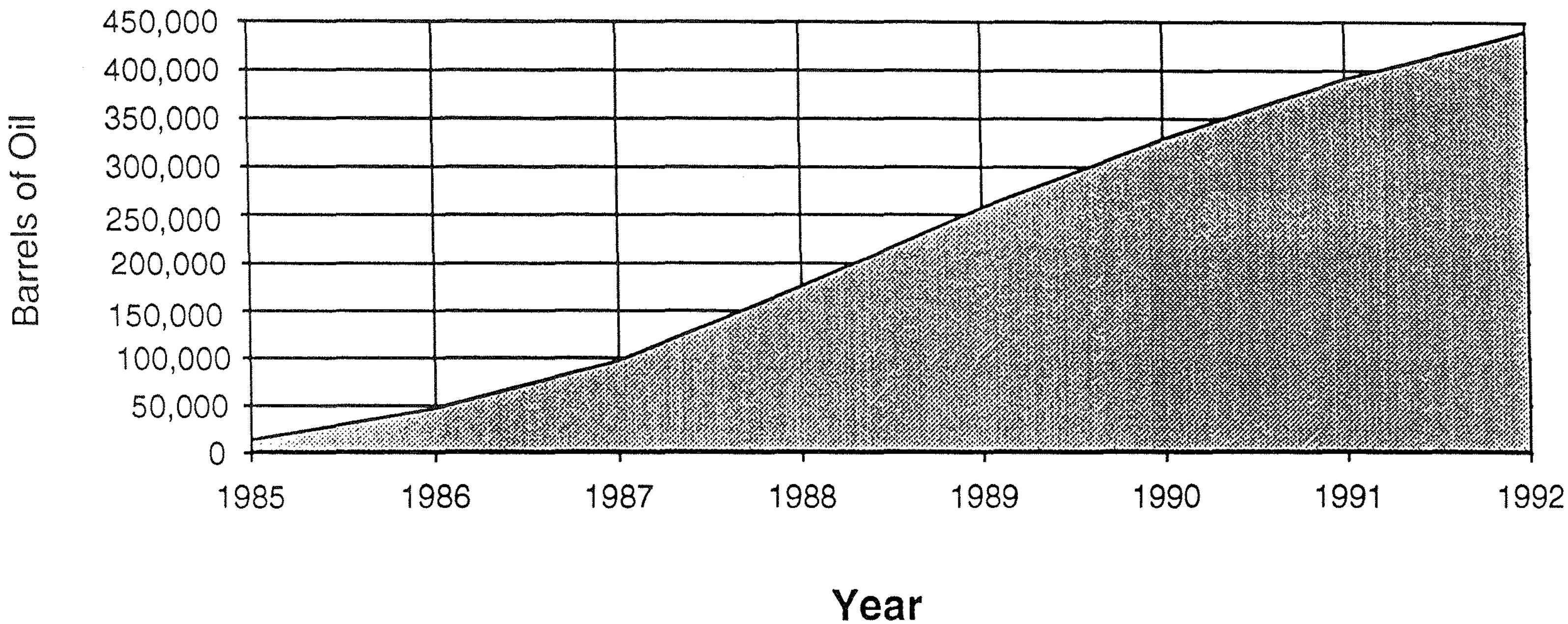
Cumulative Barrels of Oil Saved by Hawaii's Windfarms

All barrel values consider the particular utility's yearly heat rates and average BTU contents per barrel



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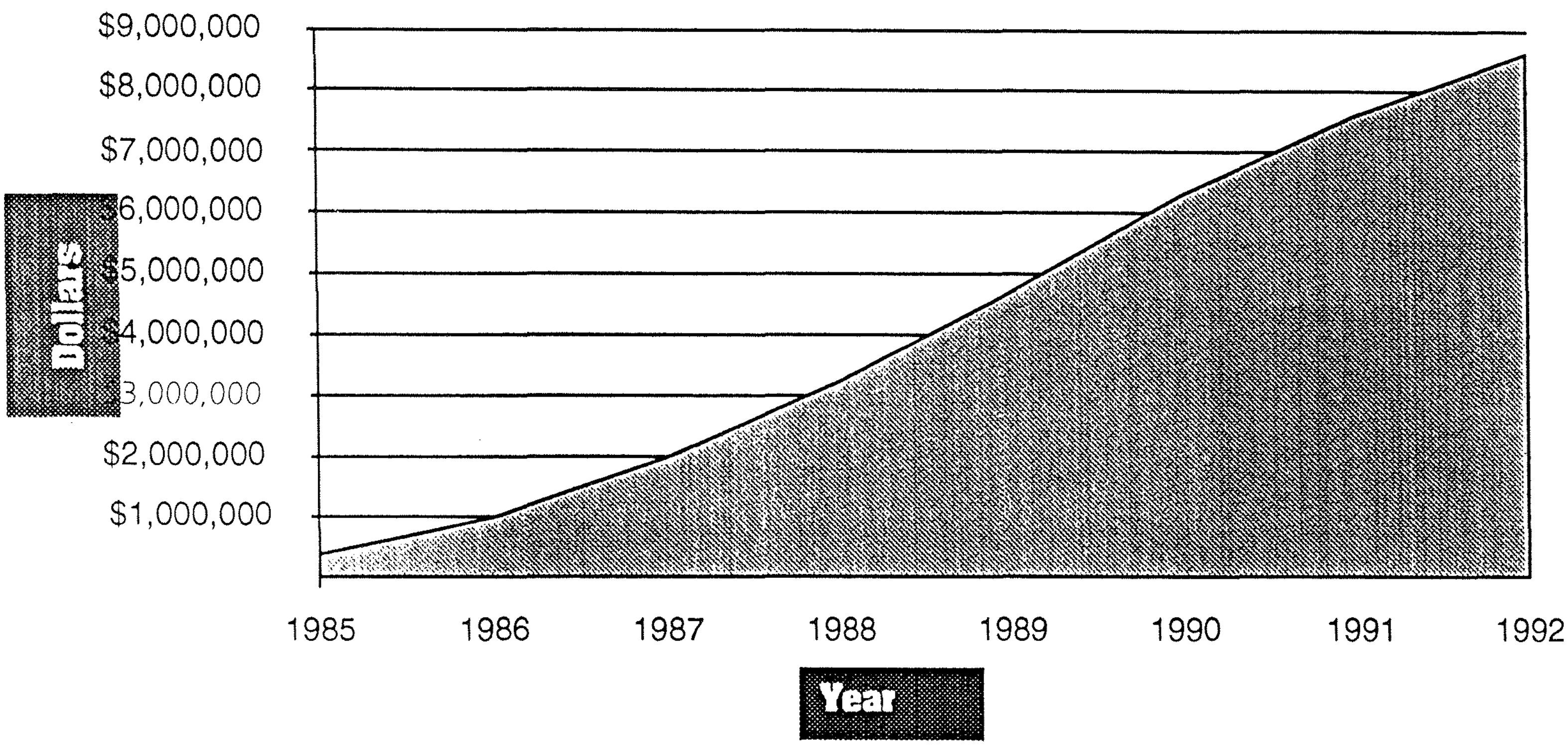
Cumulative Dollars Saved by Windfarms in Hawaii



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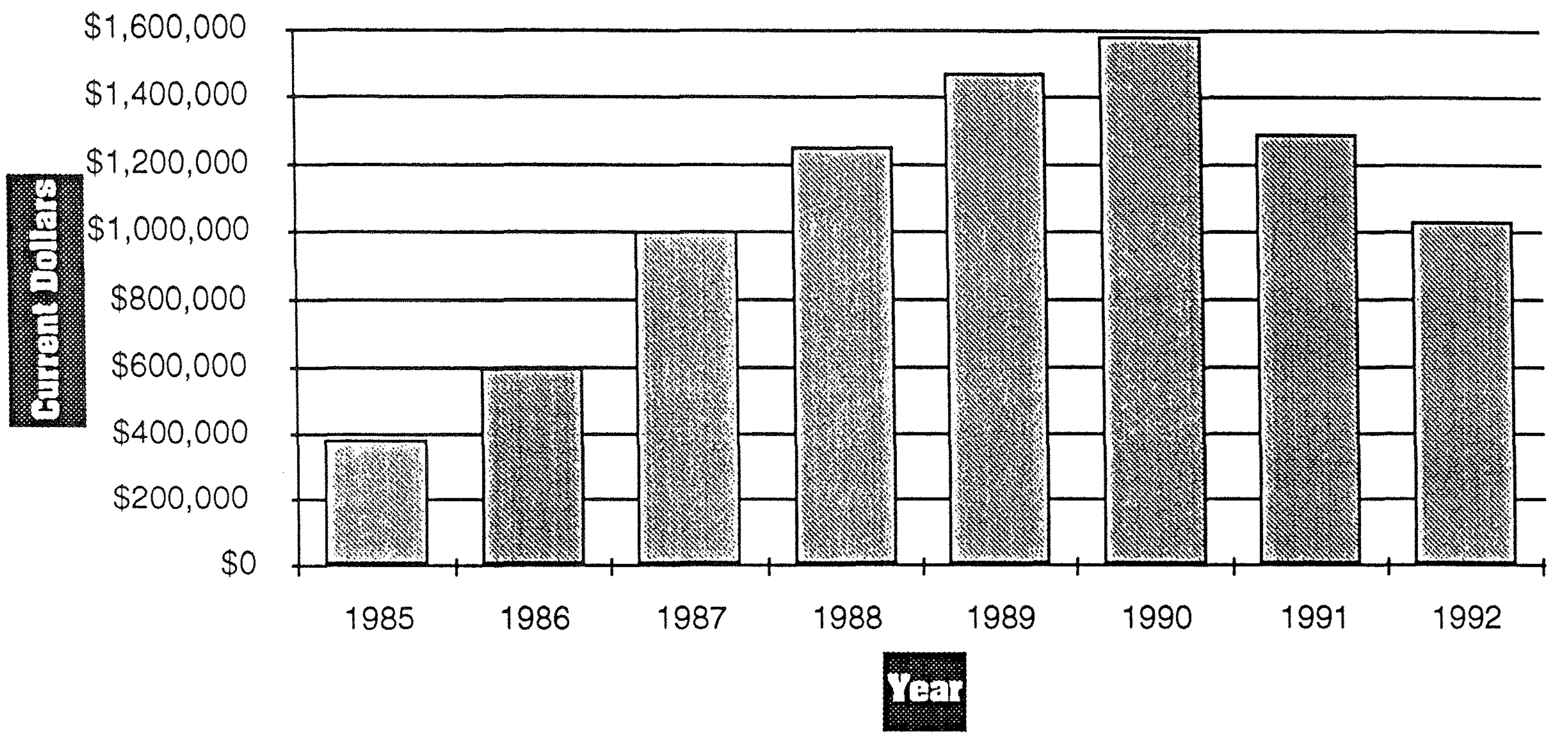
Yearly Fuel Costs Savings by Hawaii Windfarms



Lessons Learned Siting

1. Single tower wind measurements, while representative of industry practice at the time, did not provide adequate data for siting the wind turbines:

   - the windspeeds, wind shear and turbulence at individual turbine site locations turned out to be highly variable, resulting in over prediction of energy output and also contributing to higher-than-predicted wind turbine failure rates, and
   - in some cases, the period of measurements was either too short, or otherwise not representative of the long term wind, regime at the sites, resulting in over-estimation of the average windspeed.

Lessons Learned Siting

2. In some cases where the wind turbines were installed in tightly-spaced arrays:

   - energy outputs were reduced in the second and succeeding rows, due to the lower windspeeds in the turbine wakes

   - higher dynamic loads were experienced by the turbines, due to the increased turbulence in the wakes

   - higher turbine maintenance costs resulted, due to the higher-than-expected turbine failure rates

Lessons Learned Siting

The Good News

The wind industry has developed "micrositing" and "analysis" techniques which:

- identify the variations in windspeed, shear and turbulence within a proposed windfarm site
- project more accurately the long-term or annual average windspeeds
- specify appropriate turbine array layout and spacing.

Lessons Learned: Wind Turbine Design and Performance

1. The wind turbines in Hawaii are representative of older technology - production prototypes, primarily first or second generation designs:

   - production shortfalls from the wind turbines that didn't meet their predicted power curves
   - higher-than-predicted O&M costs
   - power quality problems with those wind turbines that either used induction generators or line-commutated inverters without adequate reactive power support
   - losses in revenue due to the above.

Lessons Learned: Wind Turbine Design and Performance

2. In addition, several factors exacerbated the wind turbine design process:

   - higher-than-expected "ambient" levels of turbulence combined with an initial lack of turbulence modeling capabilities
   - increases in turbulence due to wake effects
   - increase in component failures due to the salt corrosion at some sites

Wind Turbine Design and Performance

The Good News

1. Major advances have been made in wind turbine design:
   - dramatic improvements in performance and reliability
   - significant reductions in wind turbine costs
2. Progress and interest in Hawaii is growing due to:
   - efforts by existing operators to maintain and improve the output of their windfarms
   - industry interest in enhancing windpower's contribution to Hawaii's electric power supply and growing to meet market needs in the Asia-Pacific

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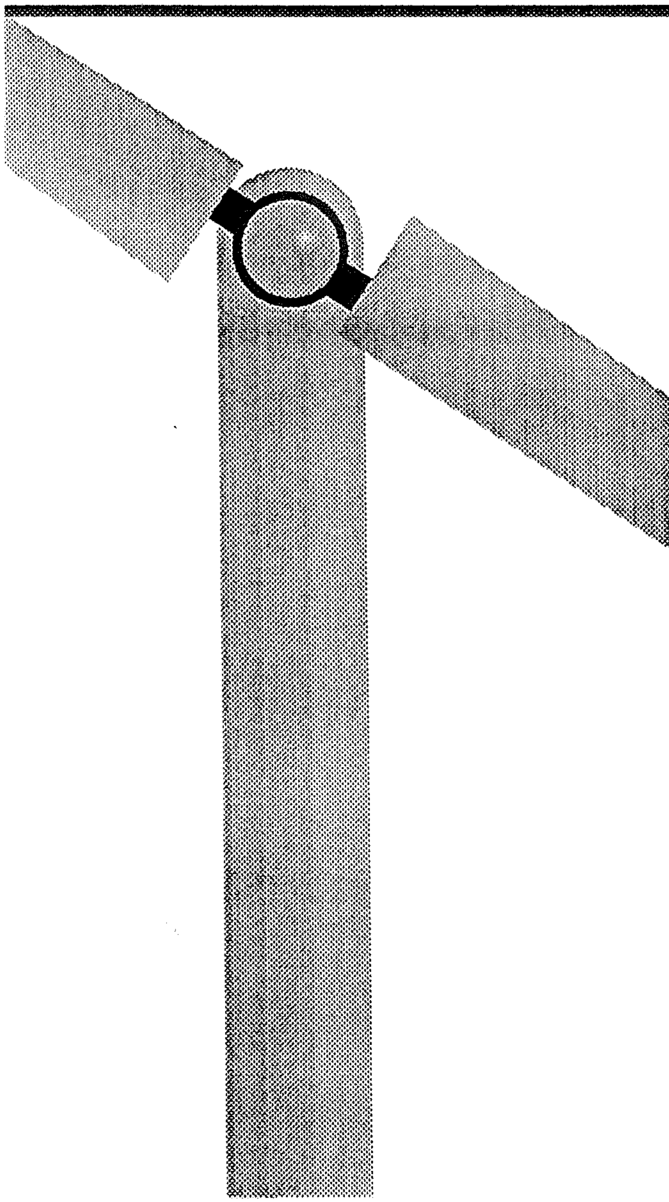

Workshop Objectives

- support the integration of additional windpower into the Hawaiian utilities supply mix by providing up-to-date information and transfer of modern wind technology to the various stakeholders in Hawaii's energy arena and
- identify appropriate mechanisms for consideration of windpower within the IRP process

Hawaii Windpower Workshop

Workshop Agenda

Five Sessions - 10 Panel Discussions

1: Introduction: History of Windpower in Hawaii

2: Technology and Resource Status *(3 Panels)*

3: Planning and Implementation Issues *(4 Panels)*

4: Key Stakeholder Perspectives *(Introductory Comments + 3 Panels)*

5: Summary, Wrap-Up and Closing Comments

Modus Operandi
Each 1 hour Panel

- One 30-minute presentation
- Three 5-minute panel member responses
- One 15-minute general "Q&A"